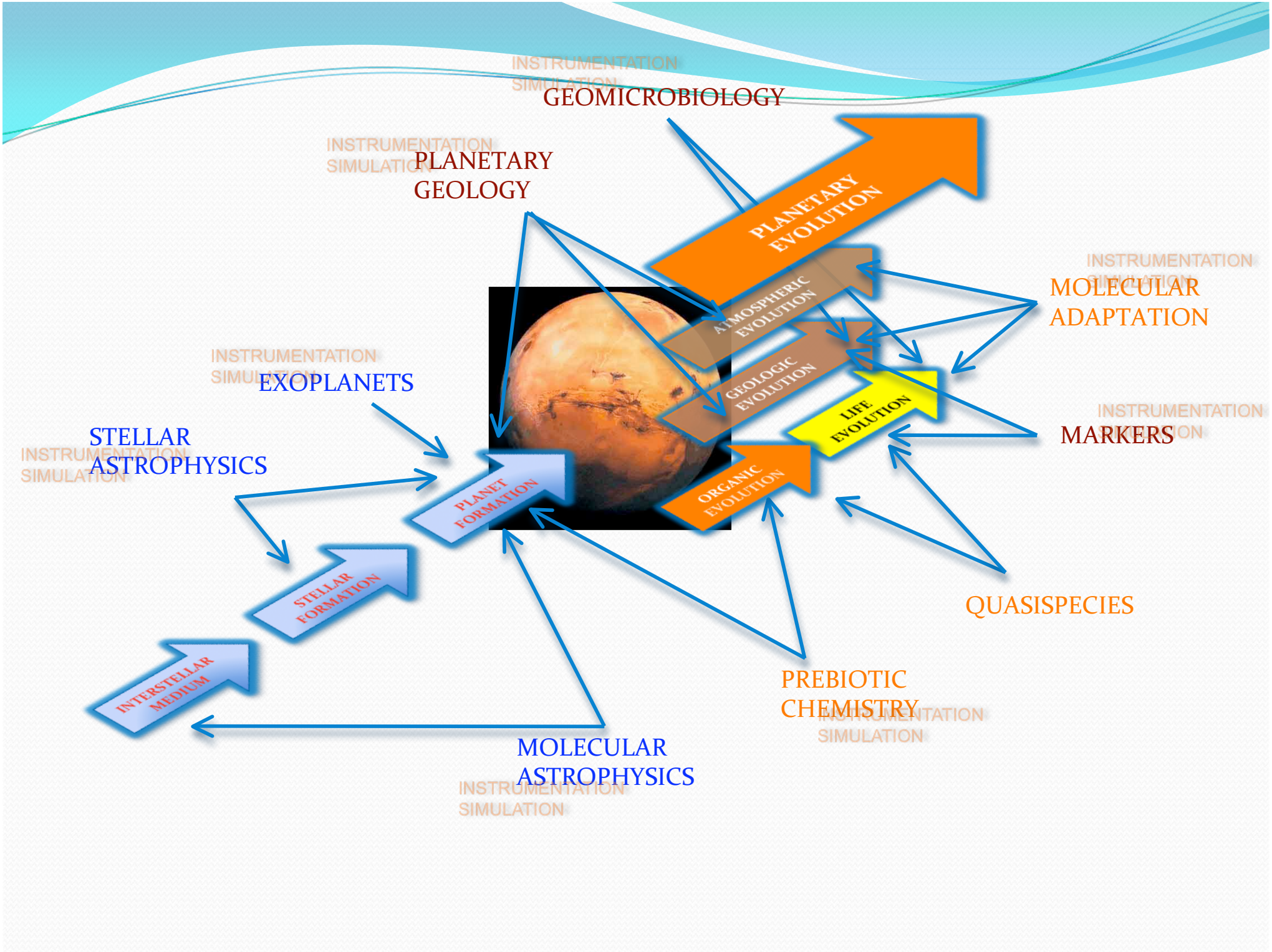
Science at the Centro de Astrobiología

Alvaro Giménez
CAB Director


GEOMICROBIOLOGY
PLANETARY GEOLOGY
PLANETARY EVOLUTION
ATMOSPHERIC EVOLUTION
GEOLOGIC EVOLUTION
LIFE EVOLUTION
ORGANIC EVOLUTION
MOLECULAR ADAPTATION
MARKERS
EXOPLANETS
STELLAR ASTROPHYSICS
PLANET FORMATION
STELLAR FORMATION
INTERSTELLAR MEDIUM
QUASISPECIES
PREBIOTIC CHEMISTRY
MOLECULAR ASTROPHYSICS

Objective 1: Astrophysics

- Formation and Evolution of the Interstellar Medium, Stars & Planets:
  - Molecular Astrophysics
  - Stellar Astrophysics and Exoplanetary Systems

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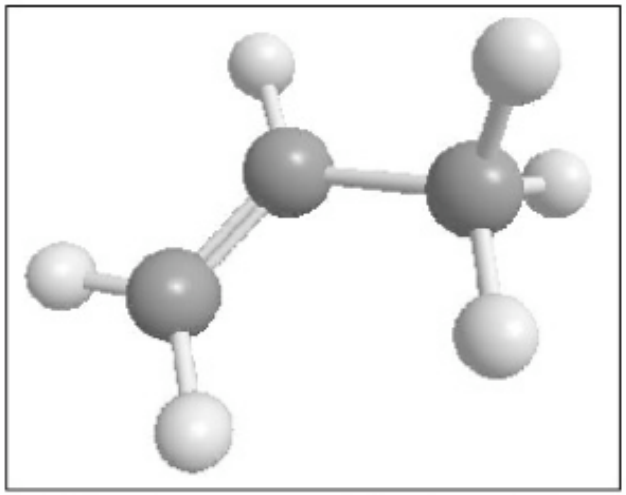
Preprint typeset using LaTeX style emulateapj v. 12/14/05

Astrophys. J. (2007), 665, L127

DISCOVERY OF INTERSTELLAR PROPYLENE (CH_2CHCH_3): MISSING LINKS IN INTERSTELLAR GAS–PHASE CHEMISTRY .

N. MARCELINO[1], J. CERNICHARO[1], M. AGÚNDEZ[1], J. MARTÍN-PINTADO[1], R. MAUERSBERGER[2], E. ROUEFF[3], M. GERIN[4], AND C. THUM[5]

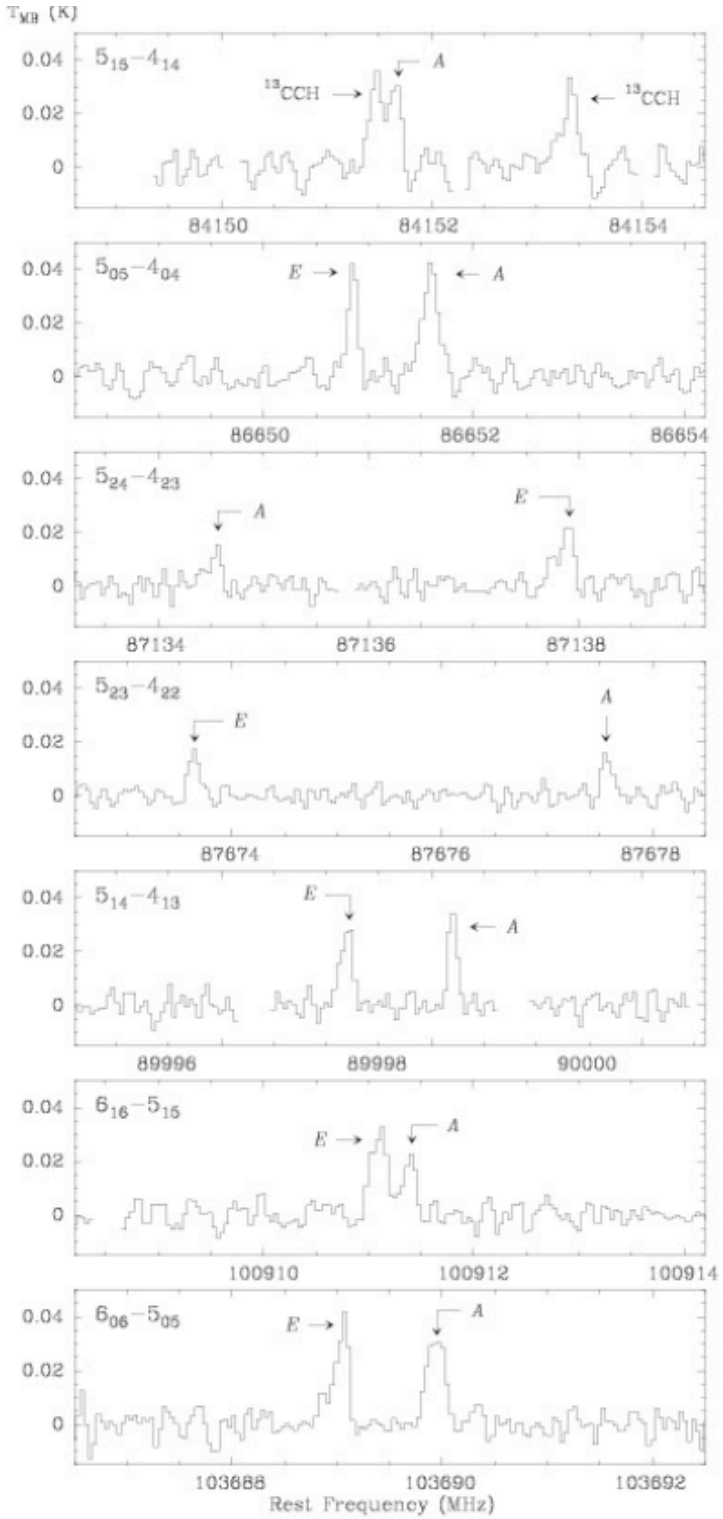


CH_2CHCH_3
Propylene,
Propene,
Methylethene

FIG. 2.— Molecular structure of Propylene. Spheres represent carbon (dark grey) and hydrogen (light grey) atoms.

We report on the discovery with the IRAM 30 m radio telescope of propylene, also called propene (CH_2CHCH_3), in the direction of the dark cloud TMC-1. Propylene is the most saturated hydrocarbon ever detected in space through radio astronomical techniques. In spite of its weak dipole moment, 6 doublets (A and E species) plus another line from the A species have been observed with main beam temperatures above 20 mK. The derived total column density of propylene is 4×10^{13} cm^{-2}, which corresponds to an abundance relative to H_2 of 4×10^{-9}, i.e., comparable to that of other well known and abundant hydrocarbons in this cloud. Although this isomer of C_3H_6 could play an important role in interstellar chemistry, it has been ignored by previous chemical models of dark clouds as there seems to be no obvious formation pathway. The discovery of this saturated species in a dark cloud indicates that a thorough analysis of the completeness of gas phase chemistry has to be done.

Subject headings: astrochemistry — line: identification — ISM: abundances — ISM: clouds — ISM: molecules



A Hot-core like molecule in a cold molecular core (TMC1)

An unexpected molecule ➔ No formation paths available in chemical models.
No frequencies in the public catalogs.
Very small dipole moment ➔ radio-astronomers have not been interested in looking for. However,➔

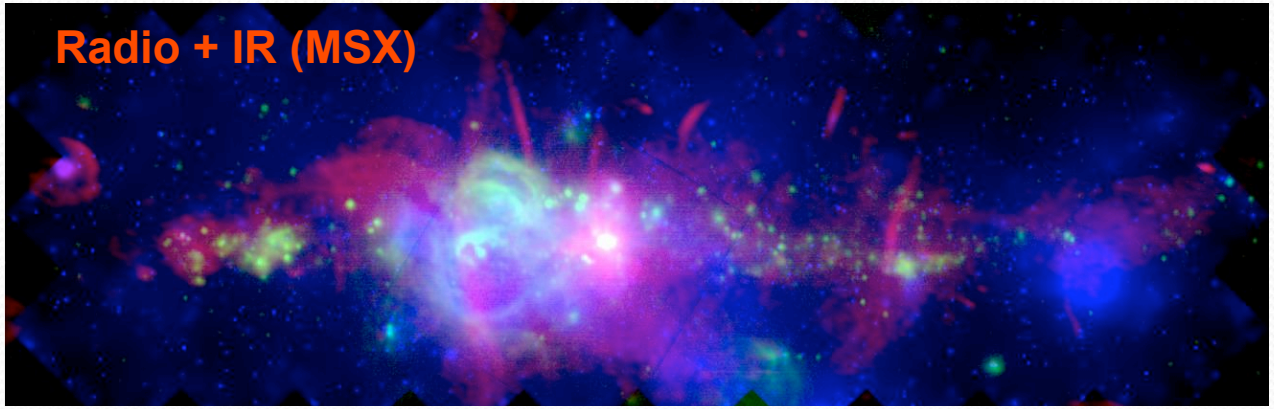
A very abundant species
$X(CH_2CHCH_3)=X(c\text{-}C_3H_2)$!!!!!

MISSING LINKS IN GAS PHASE CHEMISTRY ? OR RICH DUST SURFACE CHEMISTRY EVEN IN DARK CLOUDS

CHEMICAL AND PHYSICAL EVOLUTION OF THE GAS & DUST: FROM COLD DARK CLOUDS TO PROTO-STELLAR CORES, HOT CORINOS & HOT CORES, PROTO-PLANETARY DISKS

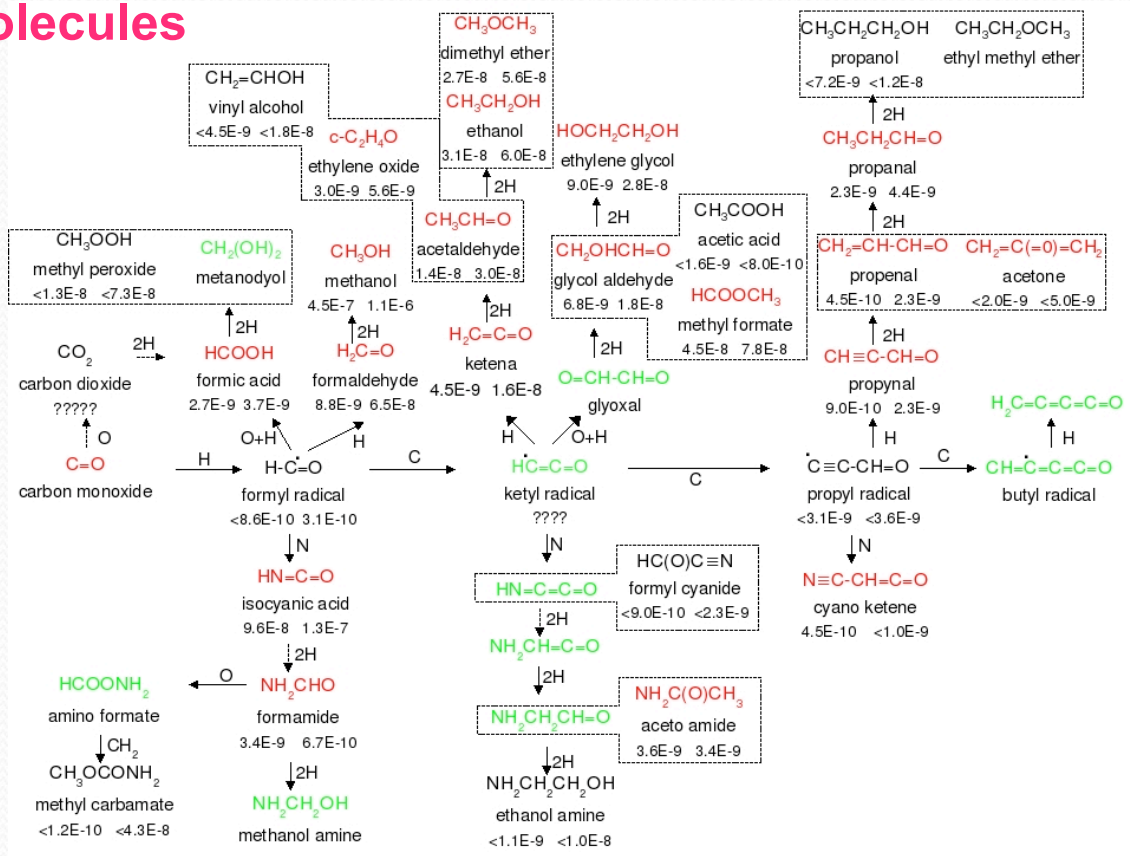
Far-IR observation (Herschel) of the bending modes of large organic molecules not Observable through pure rotational lines due to the lack or weakness of their dipole moment

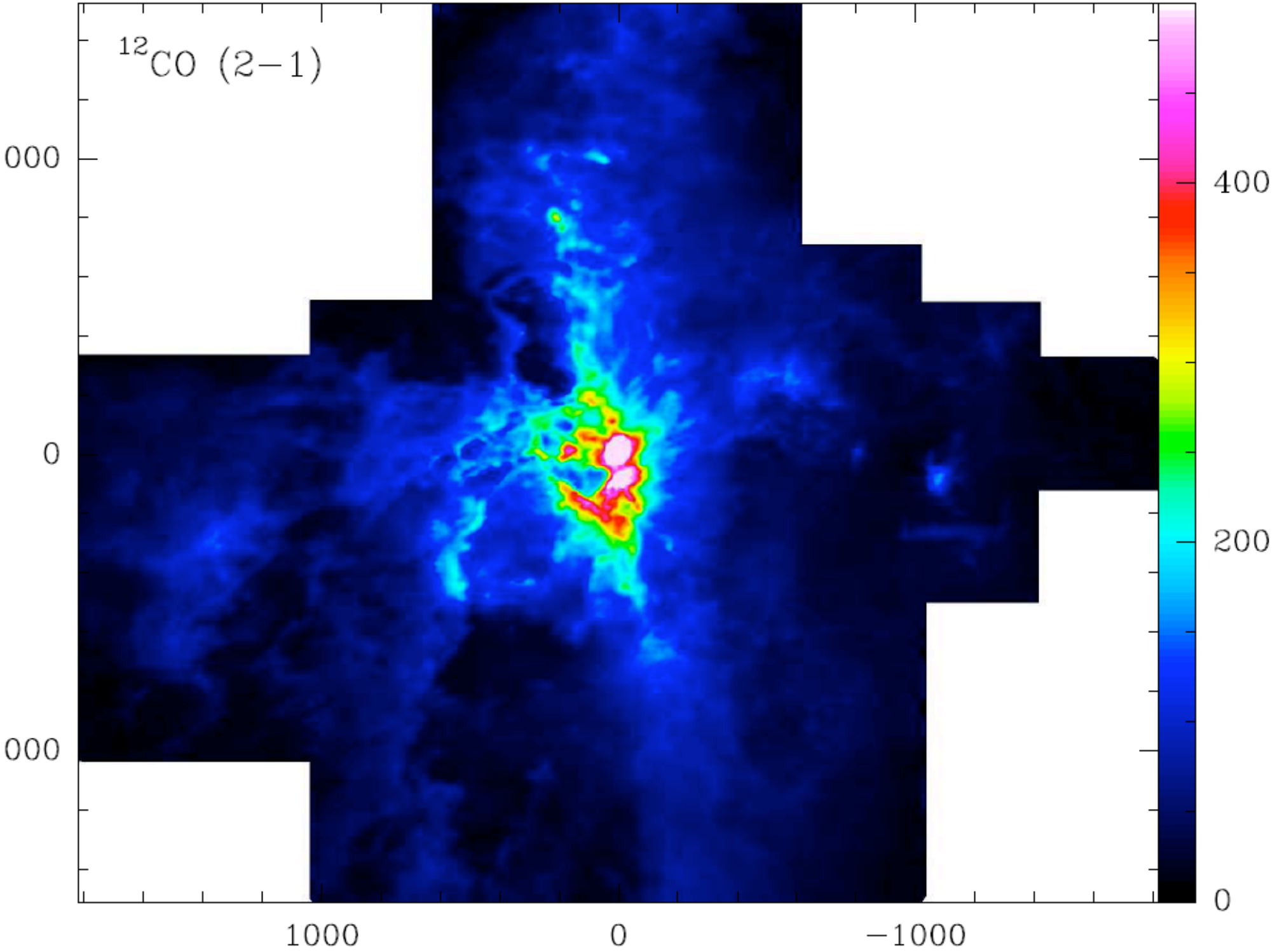
Complex organic molecules in the galaxy

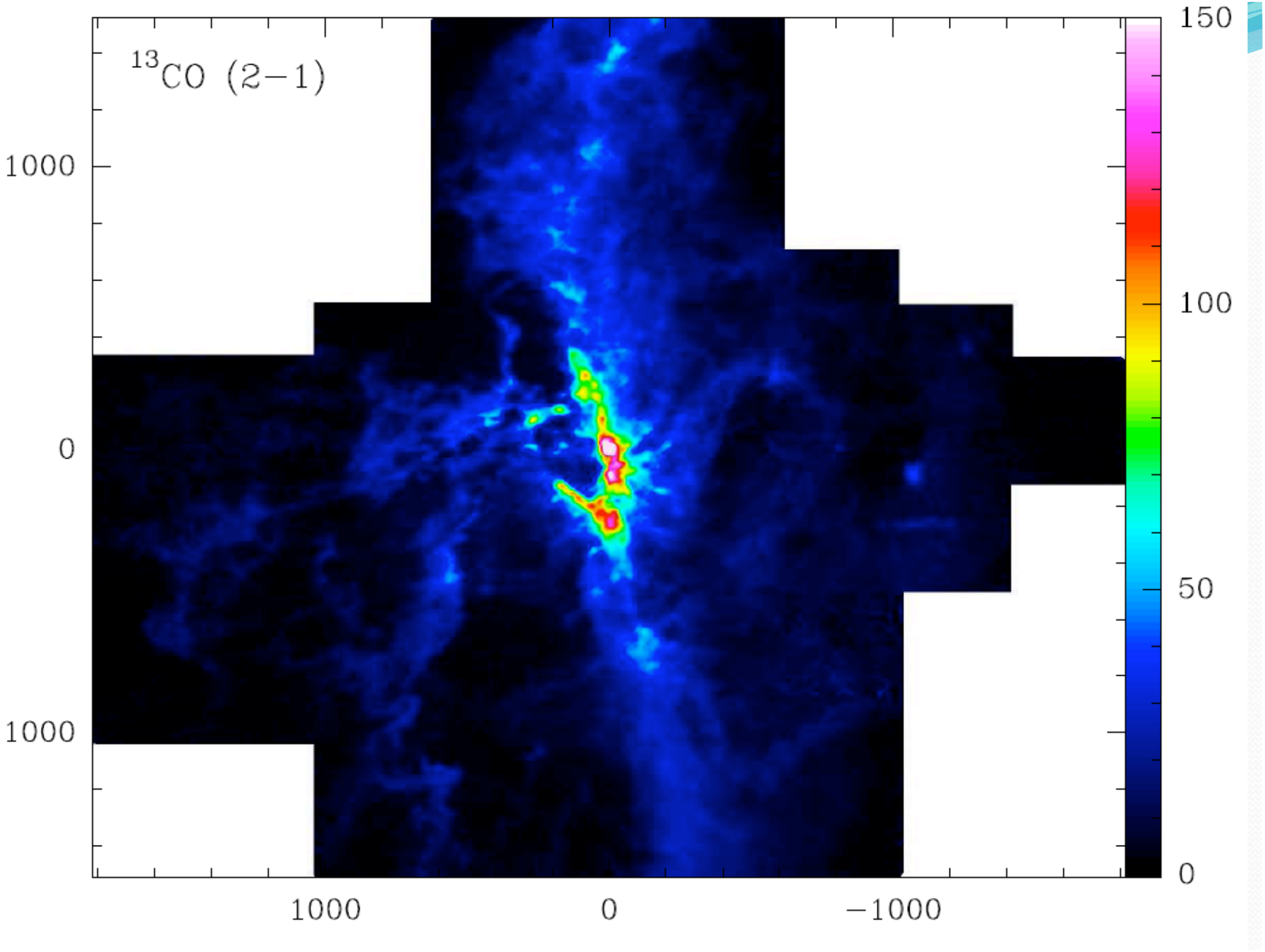


Largest abundance of complex molecules

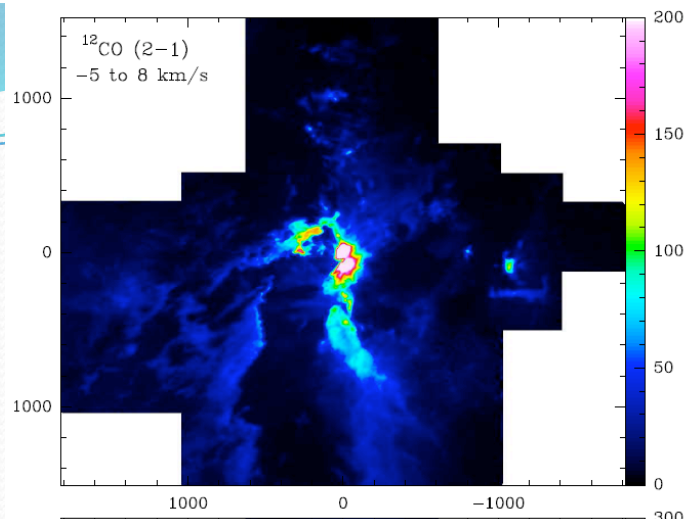
Requena-Torres et al. (2008), Astrophys. J., 672, 352.

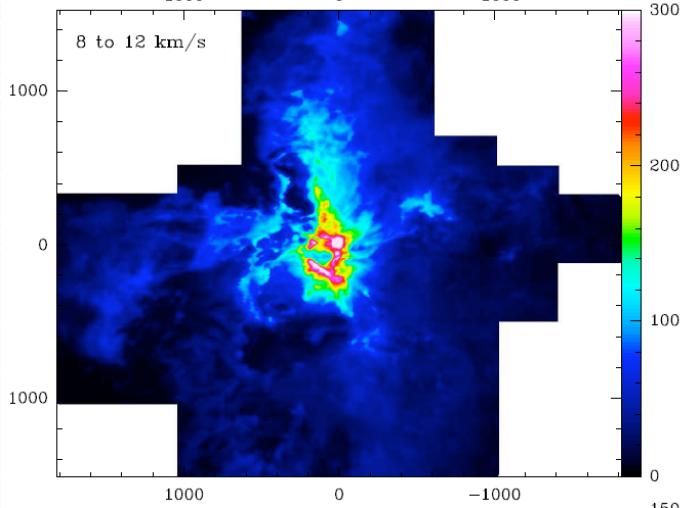


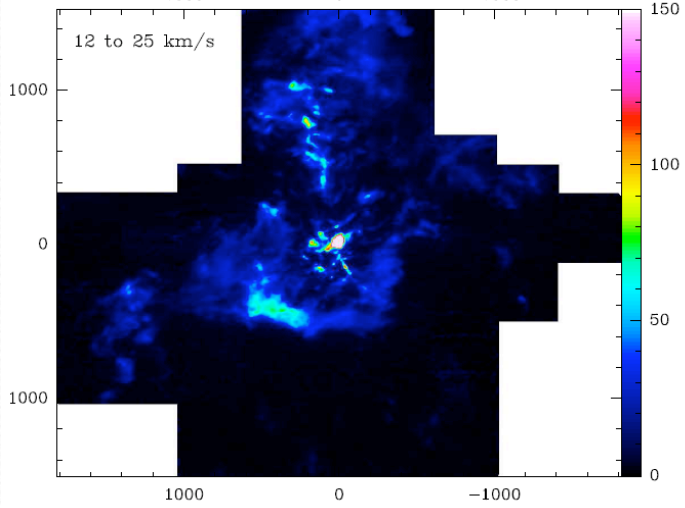

^{12}CO (2−1)
000
0
000
1000
0
−1000
400
200
0

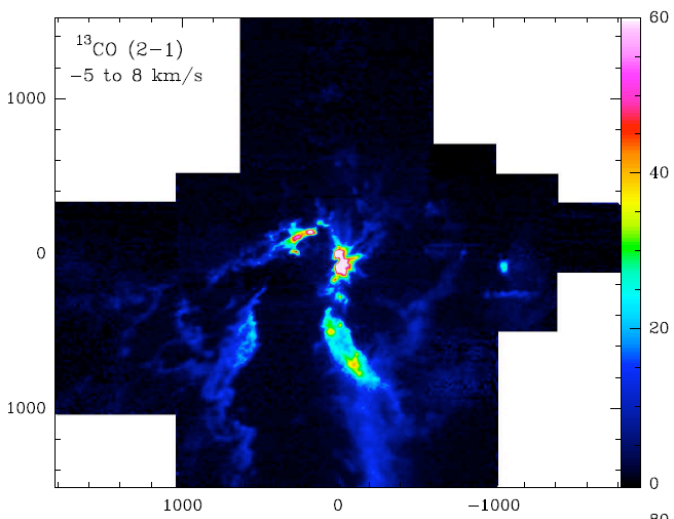

^{13}CO (2−1)
1000
0
1000
1000
0
−1000
150
100
50
0

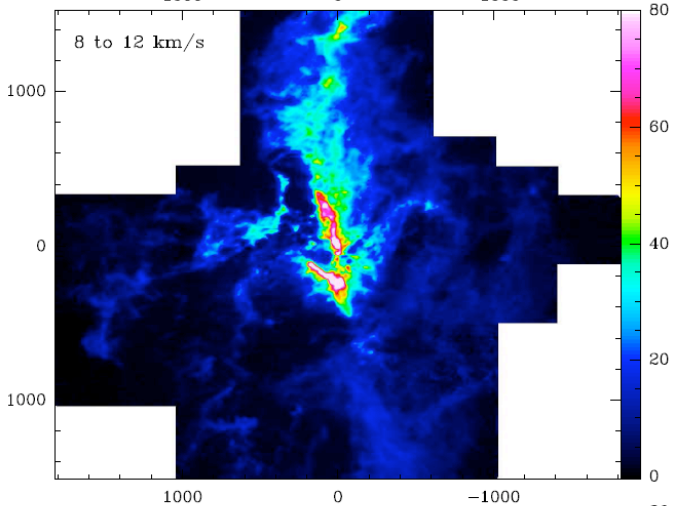
^{12}CO
J=2-1

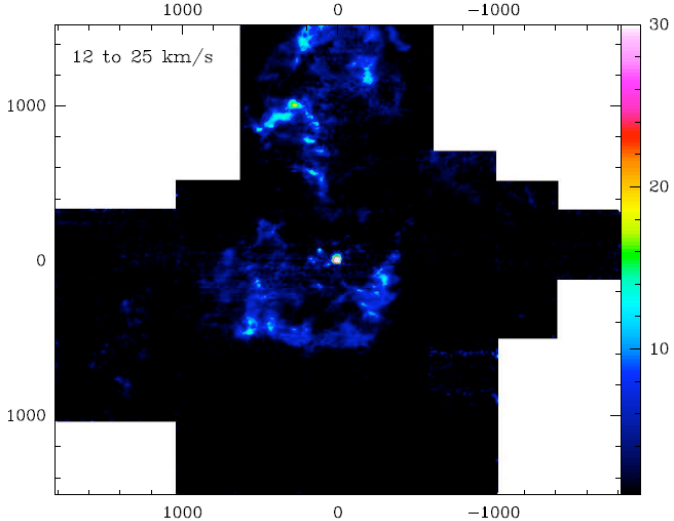








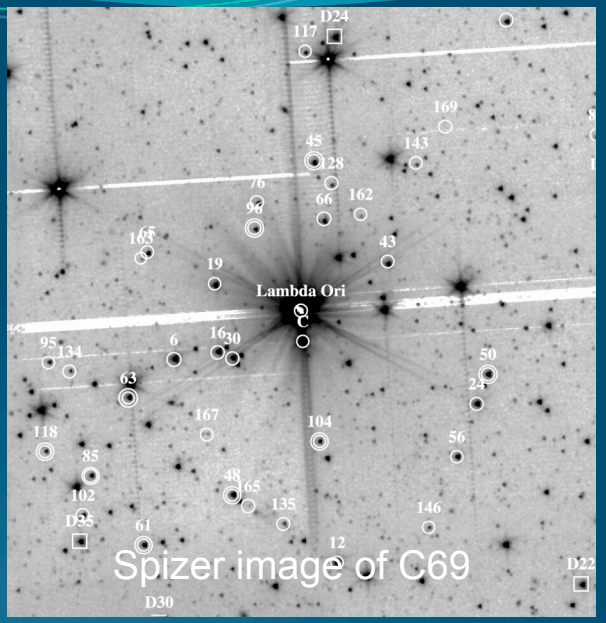




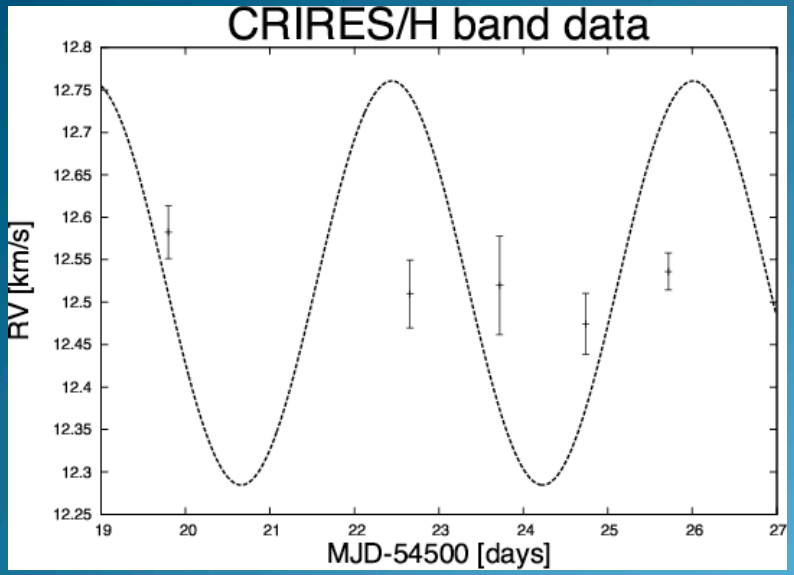
^{13}CO
J=2-1

Spitzer: Accretion in Low-Mass Stars and Brown Dwarfs in the lambda Orionis Cluster. Barrado y Navascués et al. 2007, Astrophysical Journal, vol 664, pg. 481-500

We present a comprehensive multi-wavelenght study, from the optical to the mid-infrared, of a sample of low-mass members of the 5 Myr Lambda Orionis association, study the infrared excesses, and provide additional evidences that brown dwarfs are formed by fragmentation and collapse of the parental molecular clouds.



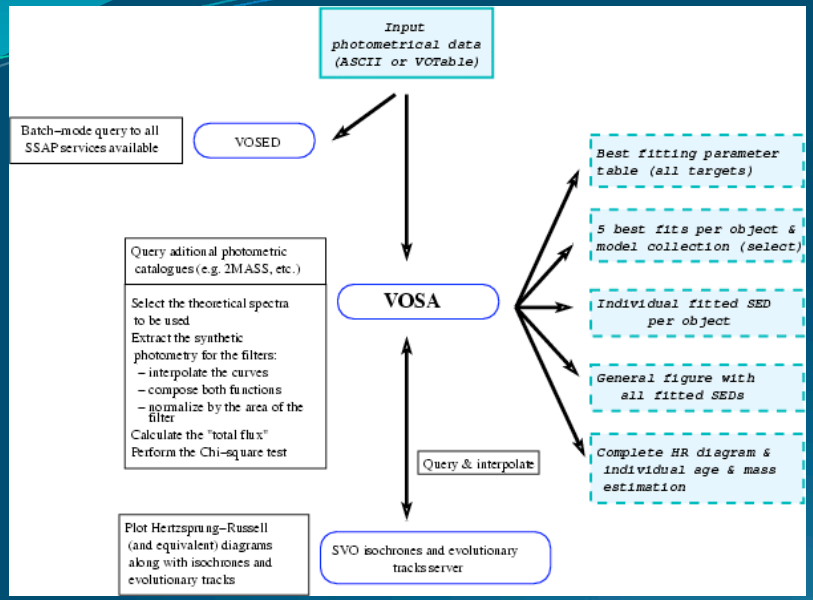
Spizer image of C69



CRIRES/H-band radial-velocity points overplotted on thethe results by Setiawan et al.

TW Hydrae: evidence of stellar spots instead of a Hot Jupiter. Huélamo et al. 2008, Astronomy and Astrophysics, Letters vol 489, pg. L9-L13

We have collected additional radial velocity measurements in the optical and near-IR (VLT/CRIRES) and show that there is not need of a planet around this bench-mark Classical T Tauri to explain the variations discovered by Setiawan et al. (2008, Nature, 451, 38).

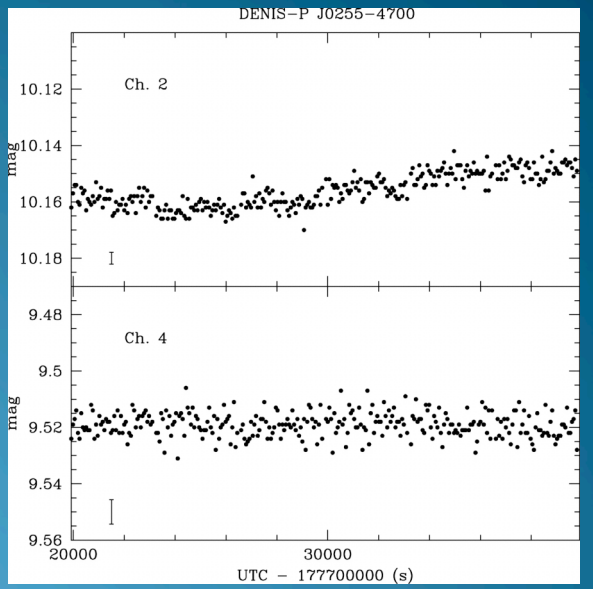


VOSA: virtual observatory SED analyzer. An application to the Collinder 69 open cluster. Bayo et al. 2008 Astronomy and Astrophysics, vol 492, pg. 277-287

We have developed an automatic procedure to perform multi-wavelength fitting to a large sample of members of a stellar association and apply this methodology to the case of Collinder 69. The method follows a work-flow to derive the physical parameters of the sources. The key step of the work-flow is performed by a new VO-tool, VOSA. All the steps in this process are done in a VO environment.

A Sensitive Search for Variability in Late L Dwarfs: The Quest for Weather. Morales-Calderón et al. 2006, Astrophysical Journal, vol 653, pg. 1454-1463

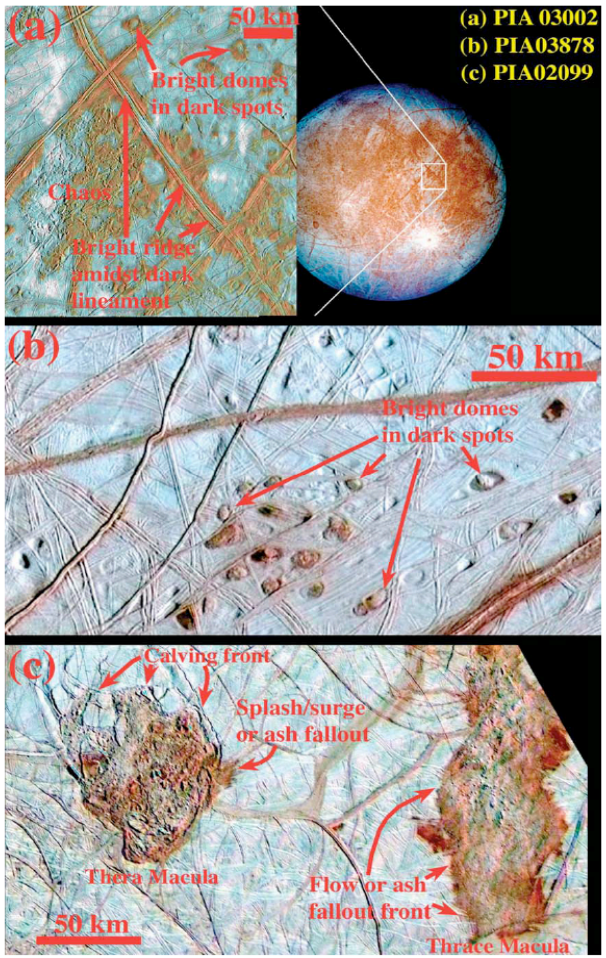
In one of the most exquisite and accurate photometric studies carried so far, we have monitored with the Spitzer Space Telescope three field late L brown dwarfs, looking for evidence of nonaxisymmetric structure or temporal variability in their photospheres. A cloud feature occupying a small percentage (1%-2%) of the visible hemisphere could account for the observed amplitude of variations. Another possibility could be either completely covered with clouds or objects whose clouds are smaller and uniformly distributed. Such scenarios would lead to very small photometric variations. In any event, these observations provide the most sensitive search to date for structure in the photospheres of late L dwarfs at mid-IR wavelengths, and our photometry provides stringent upper limits to the extent to which the photospheres of these transition L dwarfs are structured.



Objective 2: Habitability

- Evolution and Characterization of Life Environments in the Solar System:
  - Planetary Geology
  - Environmental and biological life markers
  - Geo Microbiology of Extreme Environments

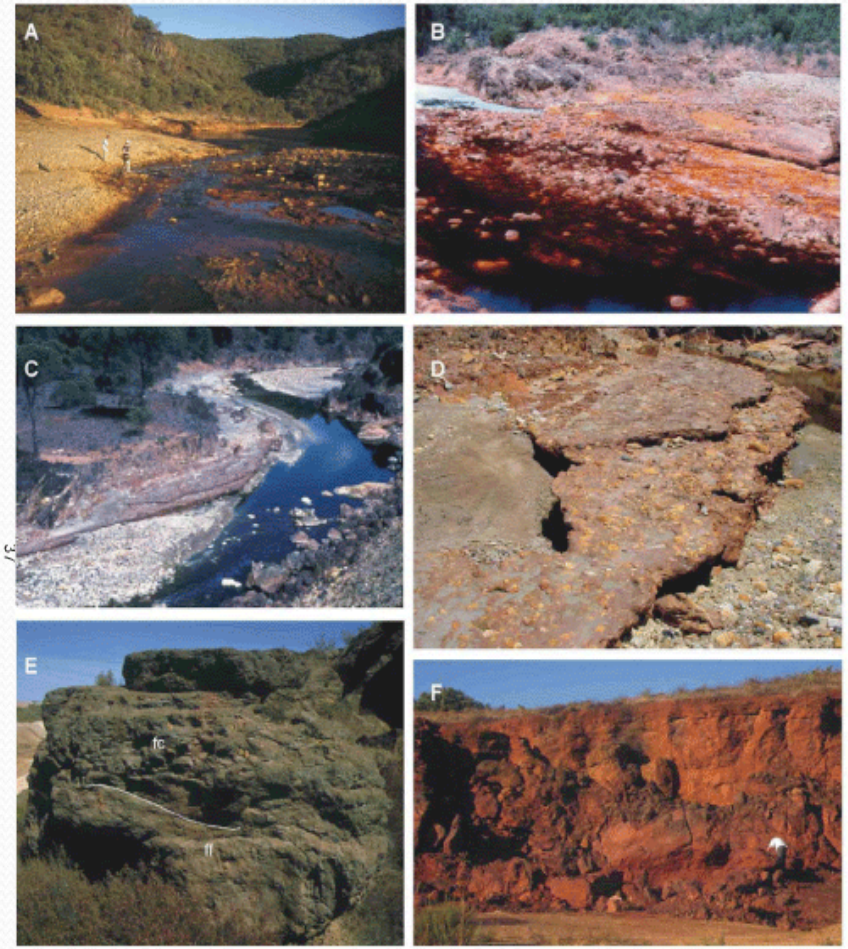
Europa's complex geology



dark/reddish material

Prieto-Ballesteros, O., Kargel, J.S. (2005) Thermal state and complex geology of a heterogeneous salty crust of Jupiter's satellite, Europa. *Icarus* 173: 212-221

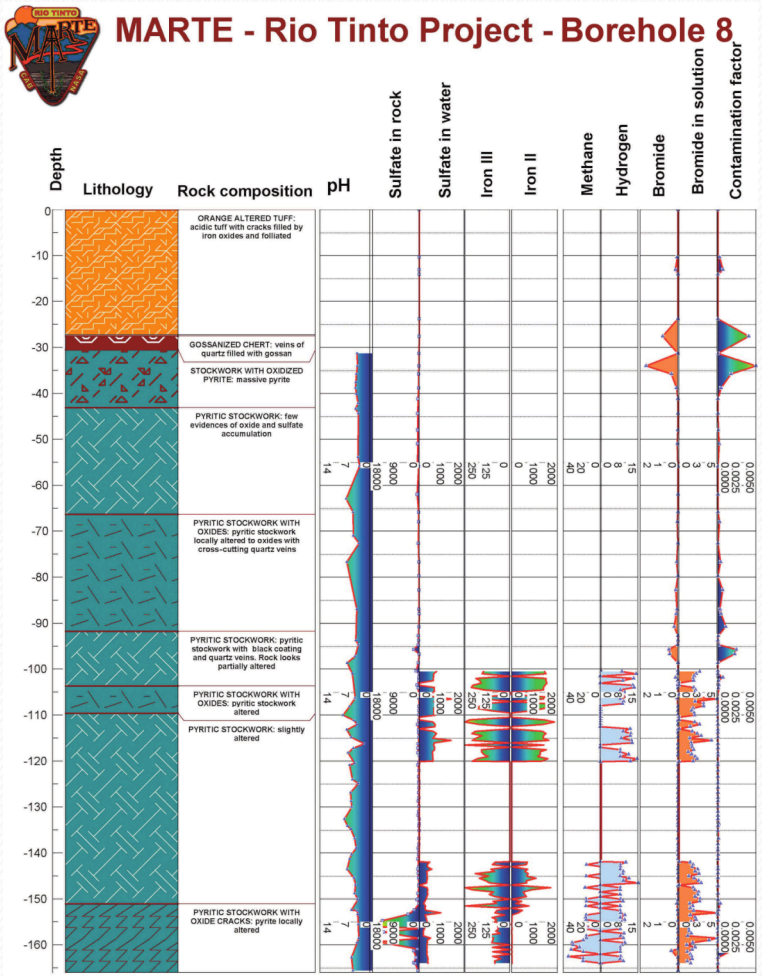
Río Tinto as a Mars analogue



Iron sedimentary minerals of different age

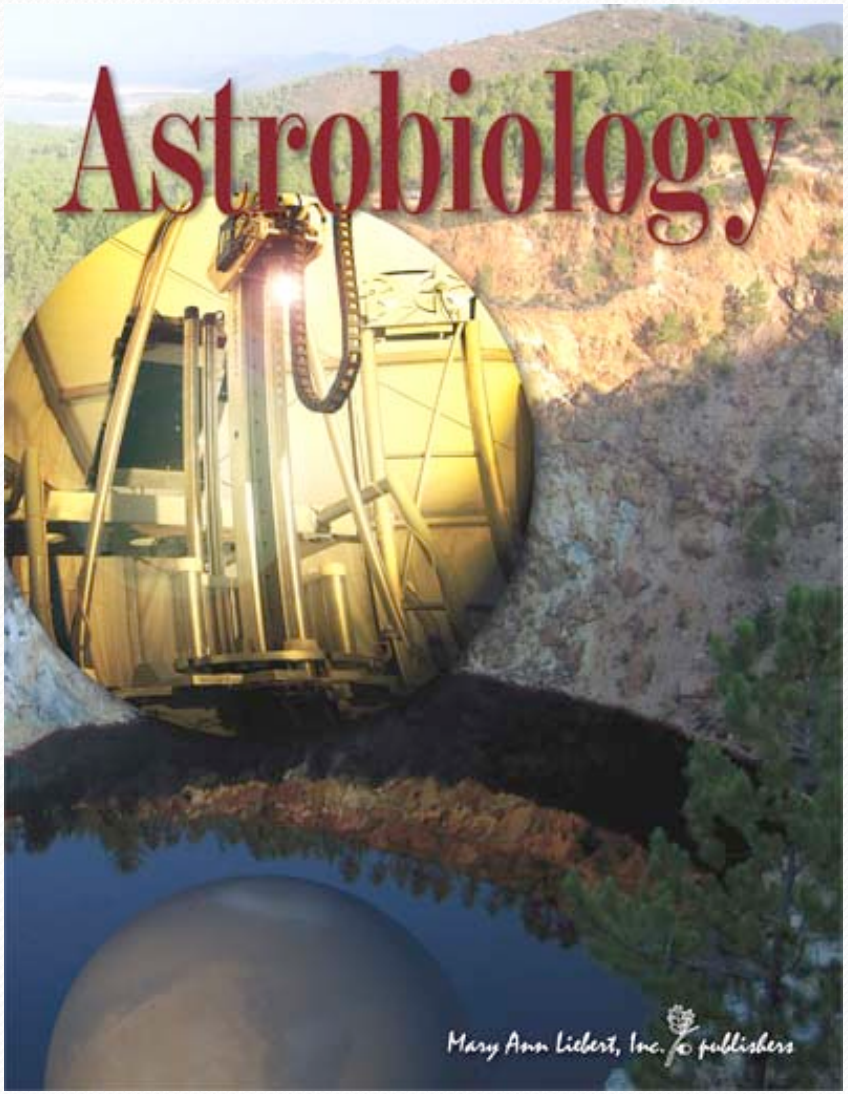
Fernández-Remolar *et al*. (2005) The Río Tinto Basin, Spain: Mineralogy, sedimentary geobiology, and implications for interpretation of outcrop rocks at Meridiani Planum, Mars Earth *Planet. Sci. Lett.*, 240: 149-167

SUBSURFACE HABITATS IN THE RIO TINTO MARS ANALOGUE

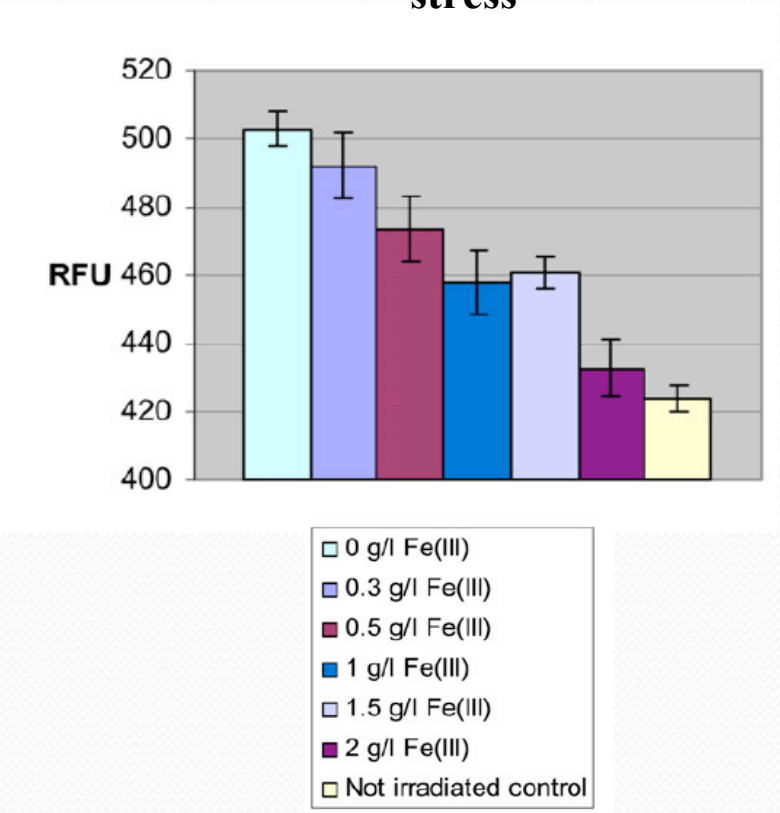


David C. Fernández-Remolar et al., (2008) Underground Habitats in the Río Tinto Basin: A Model for Subsurface Life Habitats on Mars. *Astrobiology*. 8(5): 1023-1047.

COVER AND SPECIAL ISSUE IN ASTROBIOLOGY



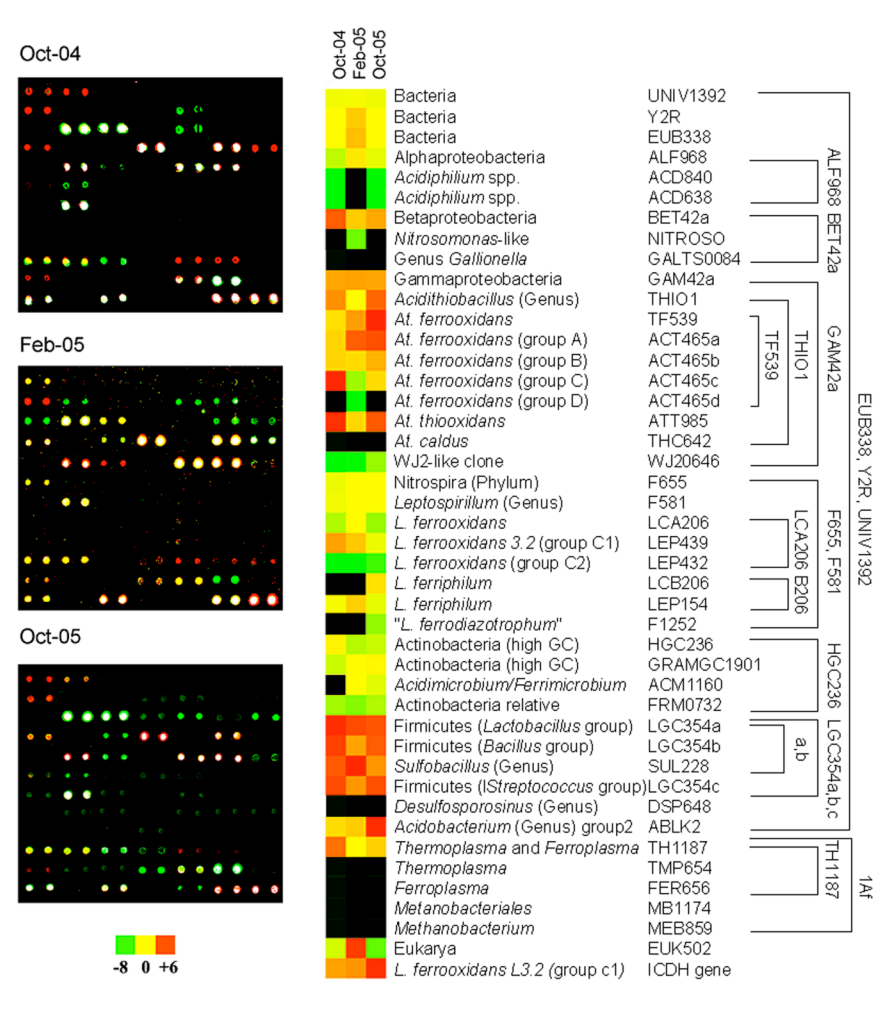
Environmental protection against oxidative stress



The protective effect of soluble ferric iron against UV radiation on acidophilic photosynthetic microorganisms.

Gómez, F., Aguilera, A., Amils, R. (2007) Soluble ferric iron as an effective protective agent against UV radiation: Implications for early life. *Icarus* 191:352-359

Fast and efficient seasonal variations of the prokaryotic diversity

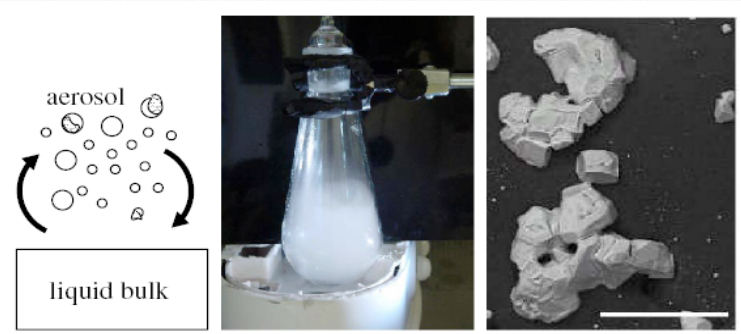


Garrido *et al*. (2008) An oligonucleotide prokaryotic acidophile microarray: its validation and its use to monitor seasonal variations in extreme acidic environments with total environmental RNA. *Environ. Microbiol*. 10: 836-850

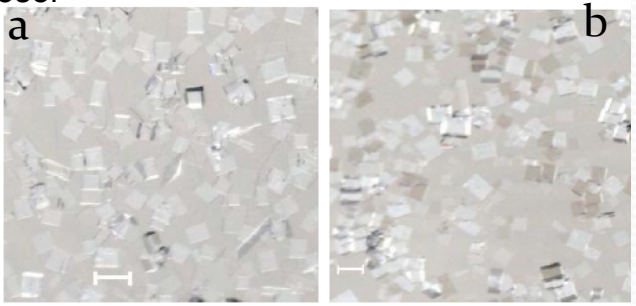
Objective 3: Molecular evolution

- Molecular Evolution and Adaptation:
  - Molecular Adaptation to the Environment
  - Evolution of Viral and Molecular Quasispecies
  - Pre-biotic Evolution

About the abiotic origin of chirality



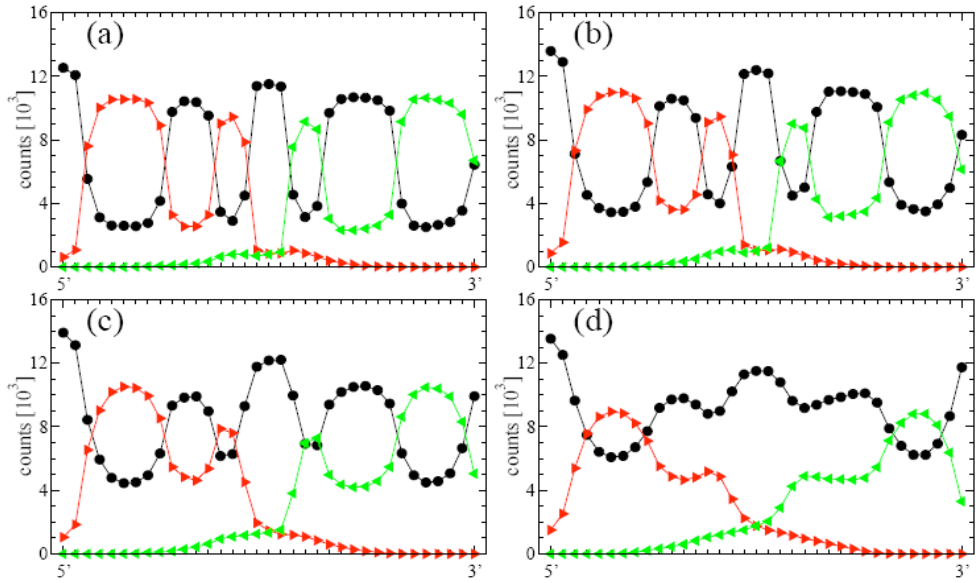
Experimental set up. Scheme of aerosol-liquid cycle; Glass reactor; SEM image of the first crystals formed in the aerosol

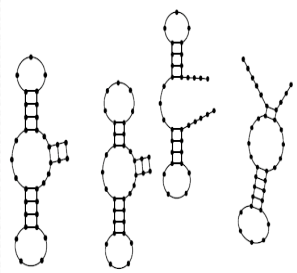


Crystal samples from the liquid bulk, taken after 4 h. (a) Homochiral case showing (*l*) polarization. (b) Racemic crystallization with roughly equal populations of (*l*) and (*d*) crystals (light and dark cubes, respectively).

Osuna-Esteban, S. et al., . (2008) Asymmetric chiral growth of micron-size NaClO3 crystals in water aerosols. *Physical Review Letters* **100** (14), 146102.

Structural stability of RNA molecules

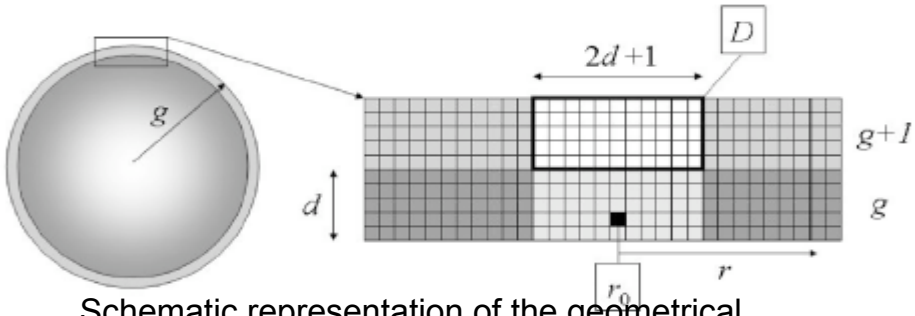




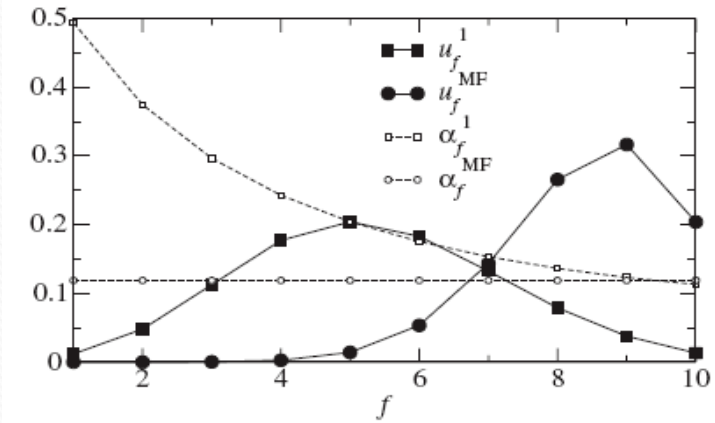
Structural stability: disintegration of collective information depends on the secondary structure, example hairpin.Implications for primitive RNA world

Stich, M., Briones, C., Manrubia, S.C. (2007) Collective properties of evolving molecular quasispecies. BMC Evolutionary Biology 7:110 IF=4.091

Molecular competition in quasispecies



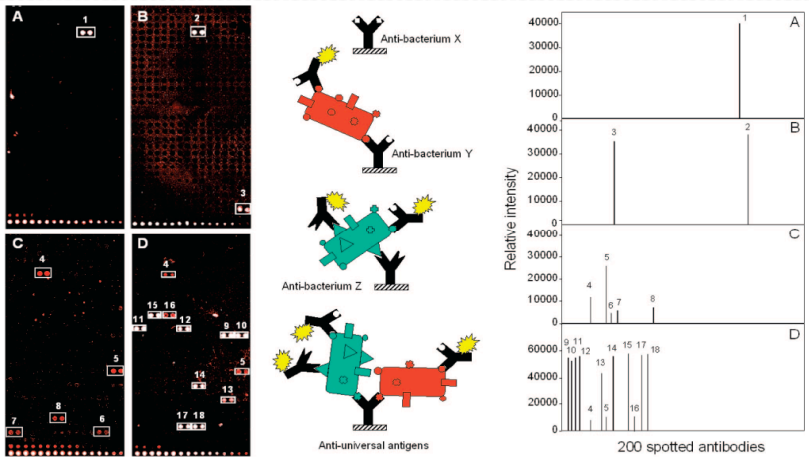
Schematic representation of the geometrical model parameters.



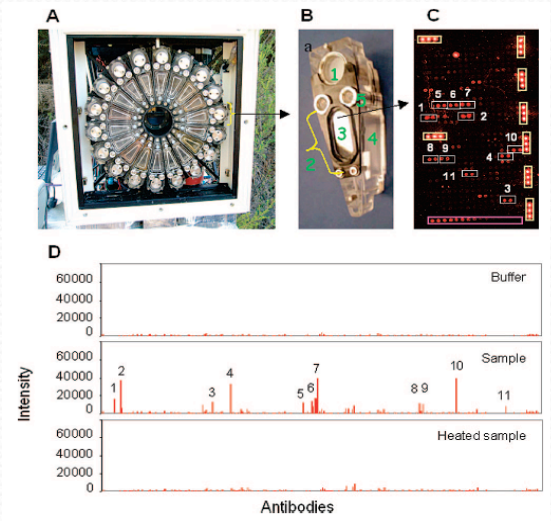
Asymptotic distribution *udf* of phenotypes in the quasispecies and corresponding values of the competition coefficients.

Aguirre J and Manrubia SC. (2008) Effects of spatial competition on the diversity of a quasispecies. *Phys. Rev. Lett.* **100**:038106. IF=6.944

A 200-antibody microarray biochip for environmental monitoring and molecular biomarker detection for astrobiology

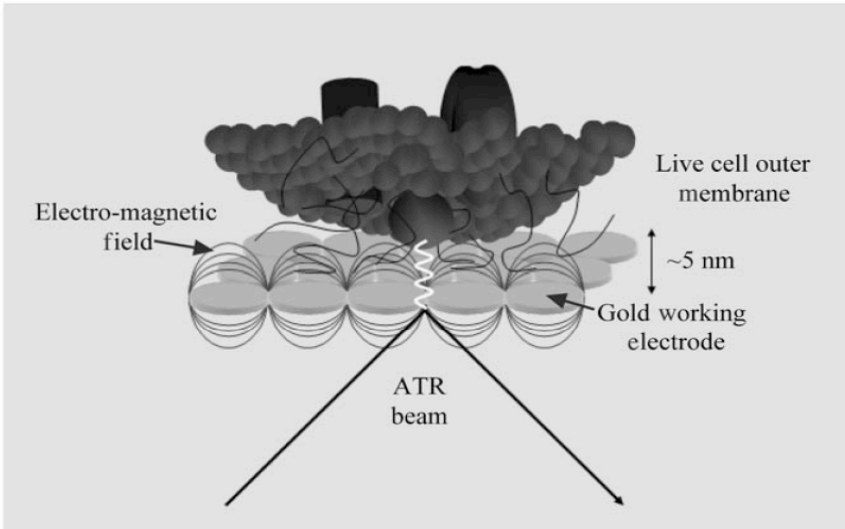


SOLID2 prototype in field campaign detected high molecular weight biological polymers



Rivas LA, et al. (2008) A 200-antibody microarray biochip for environmental monitoring: searching for universal microbial biomarkers through immunoprofiling. *Anal. Chem*. **80**:7970-9. IF=5.287

Mechanism by which bacteria transport electrons to solid electrodes



Representation of the living cell/electrode interface. The signals associated to the cell/electrode interface demonstrates that outermost membrane cytochromes in *Geobacter sulfurreducens* are responsible for the direct electron transfer to electrodes during electricity production.

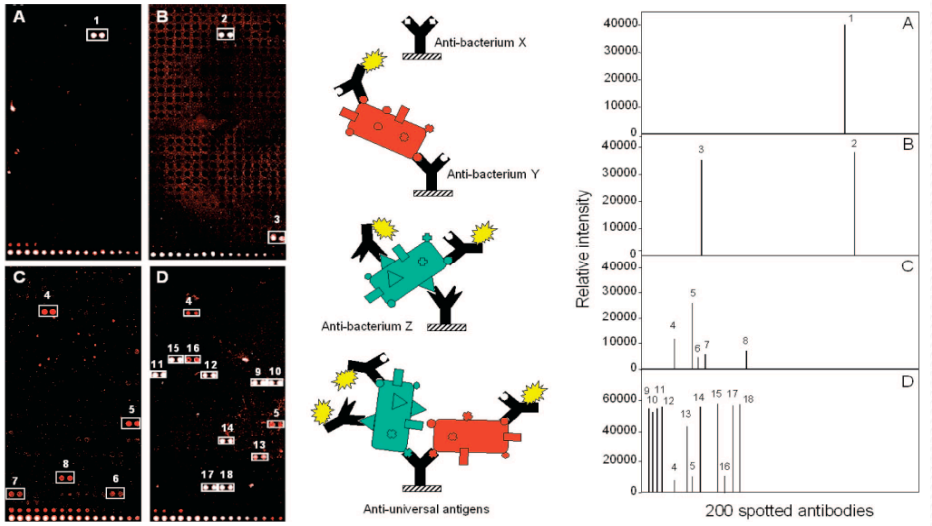
Busalmen, J.P., Esteve-Núñez, A., Berná, A., Feliu, J.M. (2008). C-type cytochromes wire electricity-producing bacteria to electrodes *Angewandte Chemie - International Edition* **47**:4874-4877. IF=10.031

Objective 4: Instrumentation

- Advanced Instrumentation:
  - Robotic Exploration and Environmental Simulation
  - Astronomical Techniques

Connection between Molecular studies, biomarkers and instrumentation

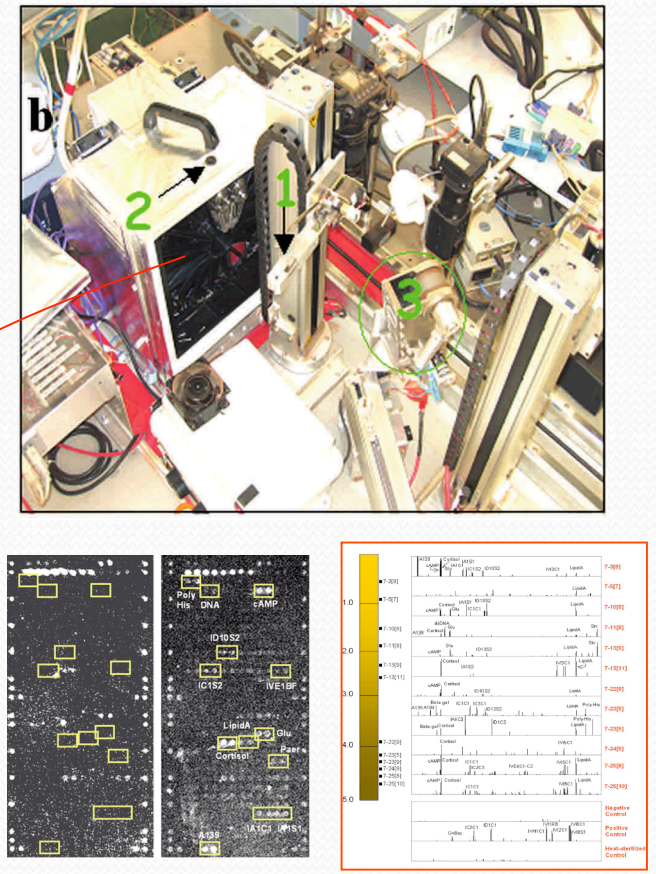
From the laboratory to the field



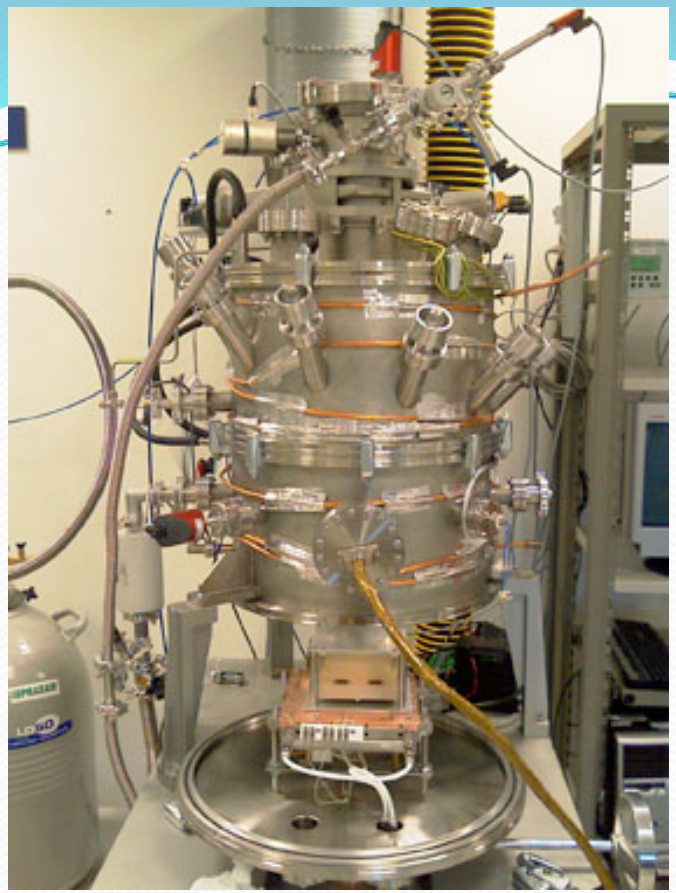
A 200-antibody microarray biochip for environmental monitoring and molecular biomarker detection for astrobiology

Rivas LA, et al. (2008) A 200-antibody microarray biochip for environmental monitoring: searching for universal microbial biomarkers through immunoprofiling. *Anal. Chem*. **80**:7970-9. IF=5.287

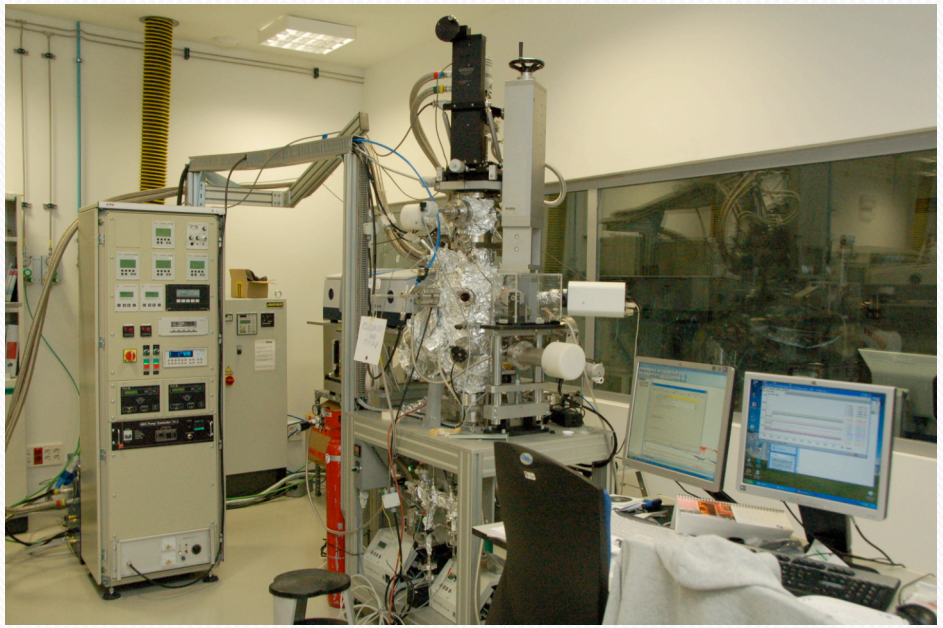
SOLID2 instrument on the MARTE drilling simulation platform detected macromolecular complexes by antibody microarray biosensor



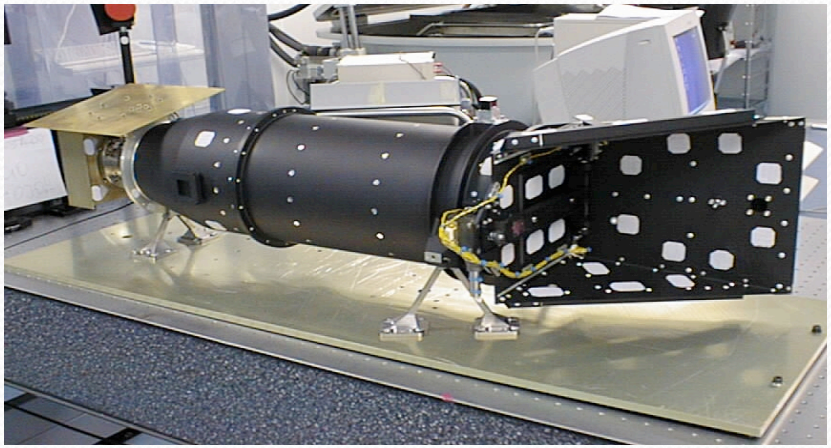
Parro V, et al., (2008). SOLID2: an antibody array-based life-detector instrument in a Mars Drilling Simulation Experiment (MARTE). Astrobiology. Oct;8(5):987-99



Mars simulation chamber

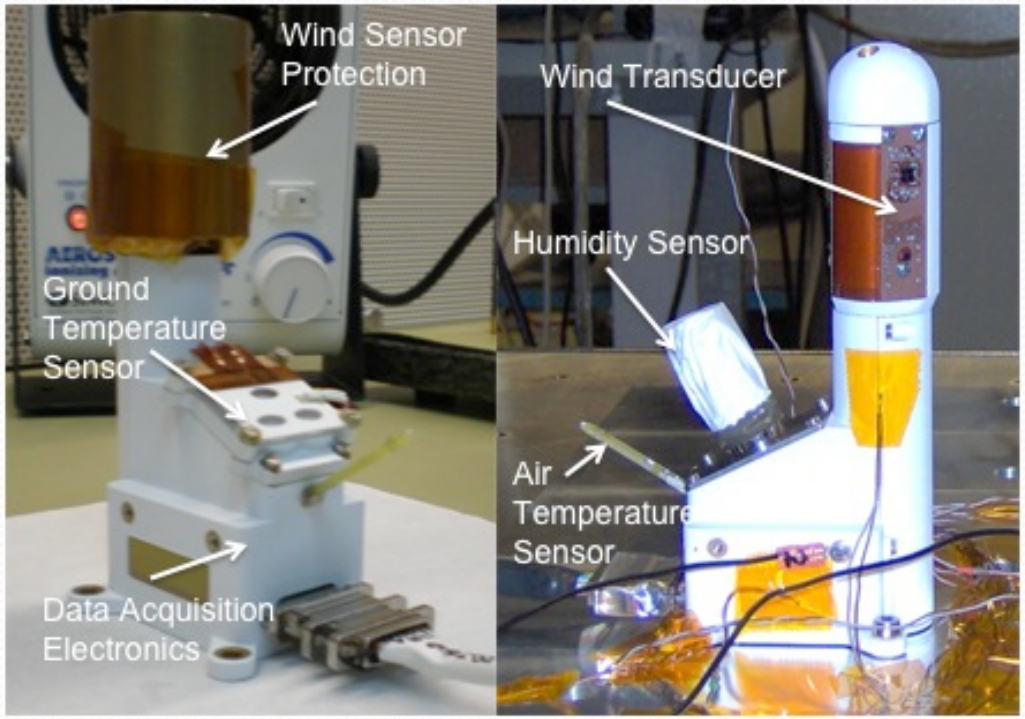


Interstellar medium simulation chamber



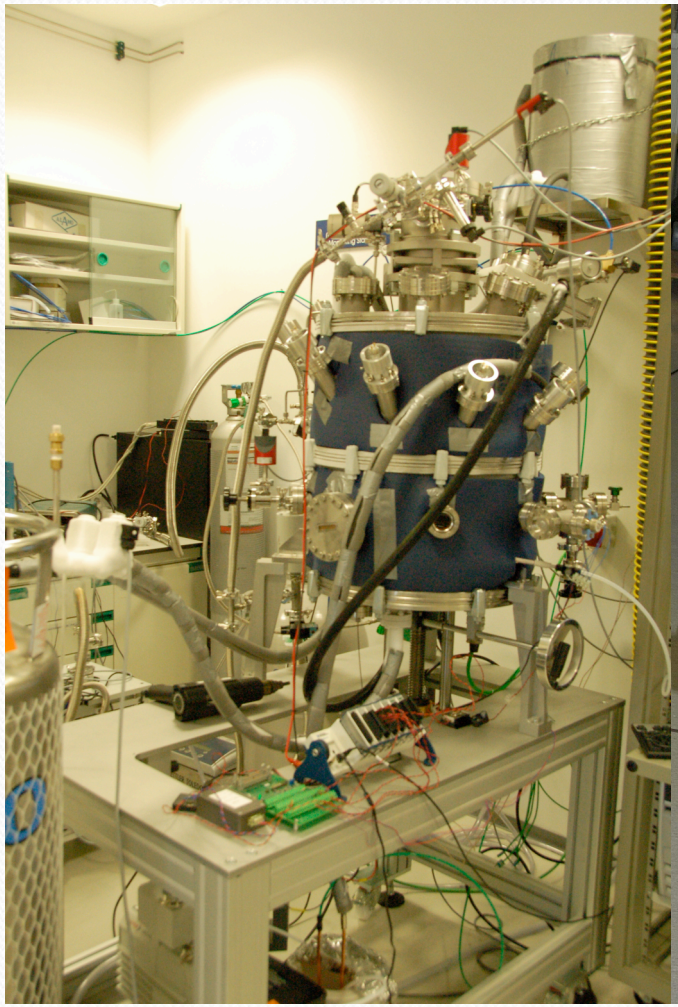
OMC-INTEGRAL

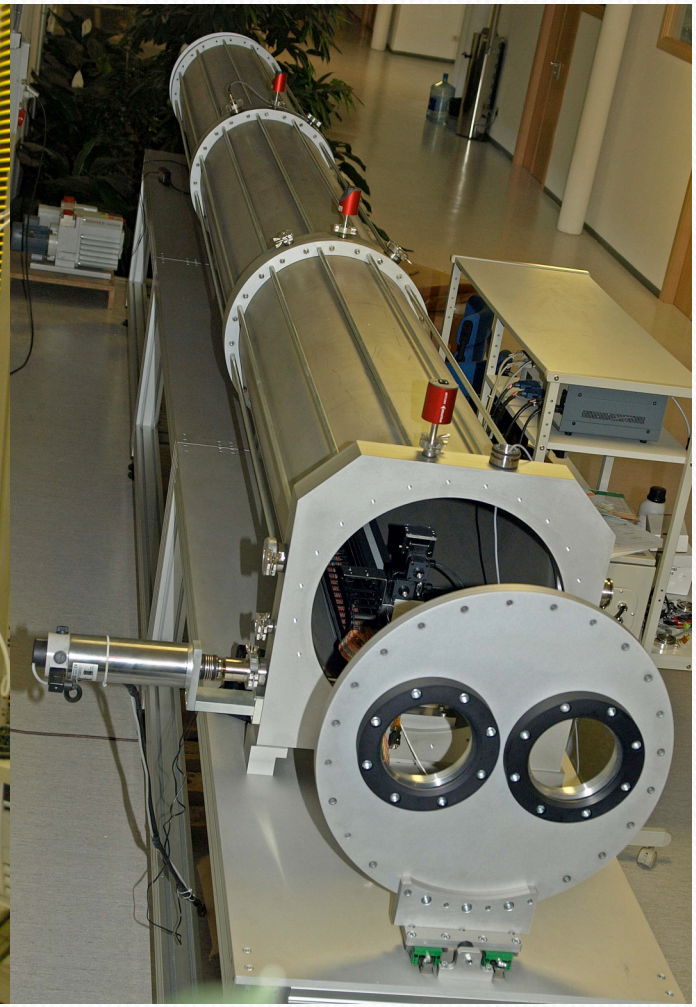
REMS (Rover Environmental Monitoring Station) has accomplished most of protoflight tests (EMC and end-to-end functional tests will be carried out in January).



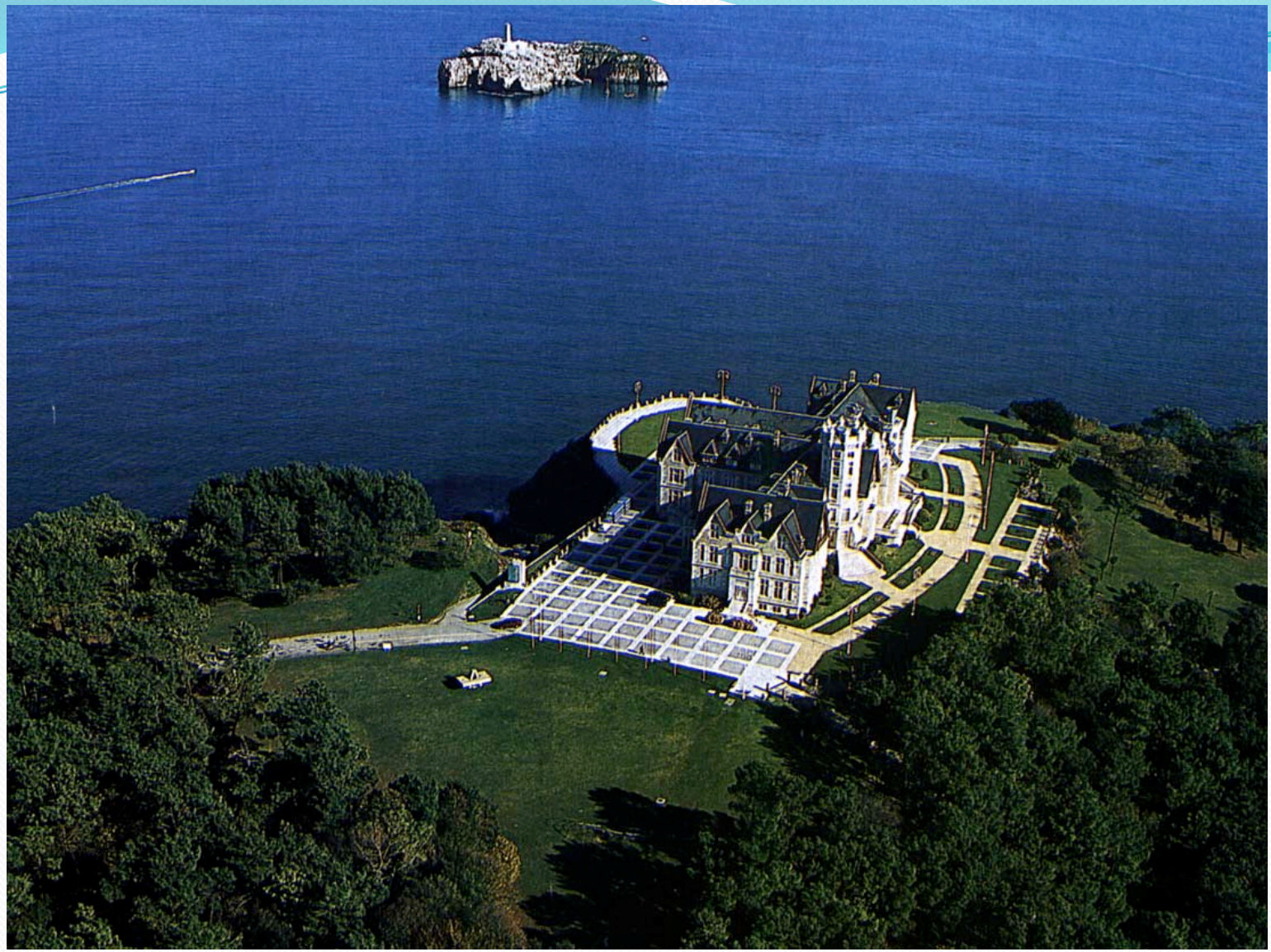
New simulation chambers have been developed for REMS testing

Chamber for simulation Mars atmosphere environment (composition, pressure, humidity, temperature), including dust.





Tunnel for testing REMS wind sensor. All range of expected wind speed could be tested on it.



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